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Status Report

ENVIRONMENTAL, SAFETY, AND HEALTH ASSESSMENT OF FY93 TASKS IN PROJECT BE9, RELATIVE PERMEABILITY

By Dan Maloney

Project BE9, Milestone 1, FY93

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Rhonda Patterson Lindsey, Program Manager
U.S. Department of Energy
Bartlesville Project Office

IIT Research Institute
NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH
P.O. Box 2128
Bartlesville, Oklahoma 74005
(918) 336-2400

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FOREWORD

This Status Report, prepared in fulfillment of Task 1 of the Annual Research Plan, describes the environmental, safety, and health (ES&H) concerns related to Project BE9 and the actions necessary to address and mitigate those concerns. The objectives of Task 1 are to review the procedures, equipment, and working conditions to ensure compliance with all federal, state, and local regulations, and to ensure that all activities are planned and conducted in a safe and environmentally sound manner. Potential areas of concern in Project BE9 include the use of flammable or toxic solvents and fluids, use of compressed gases, use of pressure vessels and moderately-high pressure systems, use of X-ray and microwave radiation techniques for measurement of fluid saturations, and use of sophisticated laboratory mechanical and electrical instruments. Each of these areas is addressed with a combination of training, standard procedures, and personal protective equipment.

Dan Maloney — Date: January 13, 1993

Dan Maloney, Senior Engineer, BE9 Project Leader

Michael P. Madden — Date: 13 January 1993

Michael P. Madden, Manager, Geotechnology

Greg Steele — Date: 1-14-93

Gregory Steele, Manager of ES&H

ENVIRONMENTAL, SAFETY, AND HEALTH ASSESSMENT OF FY93 TASKS IN PROJECT BE9, RELATIVE PERMEABILITY

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OBJECTIVE

Admiral Watkins 10-point Plan and other DOE orders emphasize the need to place high priorities on environmental, safety, and health (ES&H) issues for all NIPER activities. The objectives of Task 1 of Project BE9 are to review the experimental program for this DOE-sponsored research and to evaluate procedures, equipment, and working conditions to ensure that ES&H considerations are satisfied.

INTRODUCTION

Project BE9 is a laboratory-scale project. The volumes of wastes generated are less than 50 gallons per year. The total weight of rock specimens used for project tasks is less than 10 pounds.

Project BE9 efforts will be focused on reservoir condition two-phase steady-state relative permeability measurements for low-IFT fluid systems. The test rock will have an absolute permeability in the 300 to 1,000 mD range, which is typical of many petroleum reservoirs. Rock petrographic and petrologic properties will be well characterized. The fluid system (brine or alcohol, gas, hydrocarbon liquid) will be designed with the interfacial tensions between the brine and hydrocarbon liquid phase in the 0.01 to 0.1 dyne/cm range. Work will also be directed toward development of a simulator to evaluate how well the results from capillary pressure and steady-state relative permeabilities can be used to history-match data from unsteady-state two-phase displacement tests. Project tasks are given in Appendix 1.

Project tasks and safety considerations include the following groups of measurements:

A. Task 2 - Steady-state oil/gas/brine relative permeability measurements
   1. Moderate rock confining pressure (1,000 psig) will be applied to the rock within the pressure vessel.
   2. Test fluid injection pressures will be moderate (100 to 500 psig).
   3. The equipment will be housed in a convection oven at 150° F.
   4. The brine and gas are non-flammable. The refined oil has a flash point of 105° F and an ignition temperature of approximately 410° F.
   5. Microwave and X-ray absorption techniques are used for saturation measurements.
   6. Rock cleaning solvents may be used which have low flash points (methanol, isopropyl alcohol, pentane).

B. Task 3 - Select and characterize the test rock
   1. Rock samples may be extracted using flammable or toxic solvents (toluene, chloroform, methanol, pentane).
   2. Mercury will be used in mercury injection capillary pressure measurements.
   3. Porous plate capillary pressure measurements are made using gas pressures to 65 psi within the porous plate capillary pressure apparatus.
   4. The centrifuge may be heated for a limited number of capillary pressure/wettability measurements.

C. Task 4 - Design the test fluid and measure interfacial tensions (IFTs)
   1. The test fluids may have constituents with low flash points (C_5 - C_{11} hydrocarbons and alcohols).
   2. PVT measurements, if conducted, will be at pressures to 1,000 psig and temperatures in the 100° F to 150° F range.
   3. IFT's will be measured with pressures to 1,000 psig and temperatures to 150° F.

D. Task 5 - Conduct relative permeability measurements with the fluids of task 4.
   1. Same considerations as in part A.
   2. The brine, oil, and gas phases may have constituents with low flash points (same considerations as in part C.1).

E. Task 6 - Develop and test a coreflood simulator
   1. Same as in part A. 1.
   2. Same as in part A. 2.
   3. Same as in part A. 5.
   4. Same as in part A. 6.

POTENTIAL HAZARDS

The principle hazards associated with this work include the following:

A. Use of flammable solvents and fluids.
B. Use of compressed gases.
B. Use of various chemicals with different health and safety requirements for cleaning rock and for preparing the test fluids.
C. Working with heated pressure vessels and moderately-high pressure systems.
D. Use of X-ray and microwave radiation techniques for measuring fluid saturations.
E. Use of sophisticated laboratory mechanical and electrical instruments.

CORRECTIVE ACTIONS TAKEN OR PROPOSED

The following actions have or will be taken to limit the potential for an accident occurrence:

A. Solvents will be used in well ventilated environments and if possible within vent hoods. Personal contact with solvents will be minimized.
B. NIPER ES&H policies will be obeyed.
C. All pressure vessels will be equiped with pressure relief safety valves to prevent over-pressurization beyond safe operating pressures.
D. All ovens will be temperature controlled. The oven used for steady-state relative permeability experiments will be purged with nitrogen if necessary to reduce the oxygen content in the heated environment to a level which is below that necessary to support combustion.
E. X-ray radiation badges and rings will be worn by staff members to monitor exposures on a monthly basis as we have done in the past. Potential dosages to the public will be calculated.
F. MSD sheets will be consulted as necessary by the project staff to determine safe methods for handling and storing solvents and other chemicals.
G. Wastes generation will be minimal. Wastes will be disposed of according to NIPER ES&H policy.
H. ES&H procedures for IFT measurements are described in the BE5A ES&H Assessment.
I. Monthly ES&H inspections will be conducted by NIPER staff ordinarily not associated with the project.

J. Common sense and professional skills will be used to avoid hazardous situations. Project staff members have done similar work for Government and Industry clients for years without mishaps and are familiar with the various ES&H aspects that impact this work.

K. Monthly project meetings will be conducted. Health and safety topics relavent to project objectives will be discussed at the monthly meetings. Training, specific to the potential hazards associated with this project will be provided by NIPER scientists and EH&S personnel.

APPENDIX A—PROJECT ANNUAL PLAN

Scope of Work

Project efforts will be focused on reservoir condition two-phase steady-state relative permeability measurements for low-IFT fluid systems. The test rock will have an absolute permeability in the 300 to 1000 mD range, which is typical of many petroleum reservoirs. Rock petrographic and petrologic properties will be well characterized. The fluid system (brine or alcohol, gas, hydrocarbon liquid) will be designed with the interfacial tensions between the brine and hydrocarbon liquid phase in the 0.01 to 0.1 dyne/cm range. Work will also be directed toward development of a simulator to evaluate how well the results from capillary pressure and steady-state relative permeabilities can be used to history match data from unsteady-state 2-phase displacement tests.

Task 1. Environmental, safety and health assessment. (Start date: October 1992. Completion date: October, 1992.) (Near-Term)

Evaluate the environmental, safety, and health impact of the activities, procedures, and equipment required to conduct the tasks planned for FY93. Propose safe procedures and equipment set-up design if conflicts with NIPER's ES&H policy are identified.

Task 2. Complete multi-phase relative permeability tests at 150° F on the rock used in the FY92 program. (Start date: October, 1992. Completion date: December, 1993.) (Near-Term)

Complete unfinished reservoir condition steady-state measurements initiated during the FY92 program.

Task 3. Select and characterize rock for the FY 93 experimental program. (Start date: October, 1992. Completion date: May, 1993.) (Near-Term)

The selection process will consider using rock from the following sources: Class 1 reservoir rock, rock used by other NIPER groups for Base Program research, and rock recommended and provided by consortium members. The rock will be fairly homogeneous with little clay and with an absolute permeability in the 300 to 1,000 mD range. Rock selection will be completed by January, 1993, while characterization tasks will continue into May, 1993. The rock mineralogy will be characterized by X-ray diffraction measurements. Rock grain and pore dimensions will be measured by microscopic evaluation of rock thin-sections and by mercury injection porosimetry. Routine core properties (permeability, porosity, bulk density, etc.) will be measured. Capillary pressure characteristics will be measured using centrifuge and porous plate techniques.

Task 4. Design the test fluid (brine, gas, hydrocarbon liquid) system and equipment for measuring interfacial tensions under test temperature and pressure conditions. (Start date: November 1991. Completion date: February, 1993.) (Mid-Term)

The test fluid system should yield appropriate IFTs (0.01 to 0.1 dyne/cm range) and phase behavior characteristics at a temperature in the 100° to 150° F range and at pressures preferably below 1,000 psig. The fluid will be designed with an X-ray dopant which stays with the hydrocarbon liquid. The X-ray dopant will ensure that the X-ray attenuation characteristics of the hydrocarbon liquid phase are substantially different from those of the brine and gas. Little or no information is available in the literature describing the PVT characteristics of X-ray absorbants such as iododecane. If the fluid design uses a condensate, separate PVT measurements may be conducted on the selected X-ray dopant to provide data so that characteristics of the fluid system can be predicted by equation-of-state models. (An apparatus will be built by NIPER to measure the IFT characteristics of the fluids at the test conditions.)

Task 5 Conduct multi-phase relative permeability experiments under elevated temperature conditions. (Start date: January 1993. Completion date: June, 1993.) (Mid-Term)

Conduct two-phase steady-state gas/brine and hydrocarbon liquid/brine relative permeability tests. Modifications to the relative permeability apparatus will be made as necessary to facilitate relative permeability measurements. The system design will be influenced by the test fluid design. Two-phase steady-state measurements will be recorded during the tests at elevated stress and temperature conditions (confining pressure 1,000 to 4,000 psig, pore pressure 100 to 1,500 psig, temperature 100° to 150° F).

Task 6. Start development of a coreflood simulator. (Start date: January, 1993. Completion date: June, 1993.) (Near-Term)

Modify an existing simulator or obtain a simulator from other sources (from a consortium member or by purchase) for history matching unsteady-state displacement experiment results with relative permeabilities, capillary pressures, and other laboratory measurements. Perform unsteady-state displacements in which fluid saturations distributions are measured during the flood by CT scanning techniques. Compare saturation distributions predicted by the simulator with CT results. Report on accuracy of determinations and recommendations.

Deliverables

Oct 92	Status report on environmental, safety, and health analysis.
Aug 93	A chapter in the NIPER Final Technical Report summarizing the accomplishments of the project BE9.
Sep 93	Topical report describing two- and three-phase relative permeability and other experimental results.

IDENTIFICATION OF TRAINING NEEDS

- ☒ Employee Emergency Plans/Fire Prevention
- ☐ Noise
- ☒ Flammable/Combustible Liquids
- ☐ Hazardous Waste Operations and Emergency Response (HAZWOPER)
- ☐ Medical and First Aid
- ☐ Lockout/Tagout
- ☐ Occupational Exposure to Hazardous Chemicals in the Laboratories
- ☐ Bloodborne Pathogens
- ☐ Other
- ☐ Ventilation
- ☒ Radiation
- ☐ Storage and Handling of Liquefied Petroleum Gases
- ☐ Respiratory Protection
- ☐ PPE
- ☒ Toxic and Hazardous Substances
- ☐ Hazard Communication
- ☒ Portable Fire Extinguishers

HAZARDS IN THE WORKPLACE

☐ OSHA Controlled Chemicals:

- ○ Air contaminant PELs/TLVs
- ○ Asbestos
- ○ Coal Tar Pitch Volatiles
- ○ 4-Nitrobiphenyl
- ○ alpha-Naphthylamine
- ○ Methyl Chloromethyl Ether
- ○ beta-Naphthylamine
- ○ Benzidine
- ○ 4-Aminodiphenyl
- ○ Ethyleneimine
- ○ beta-Propiolactone
- ○ 2-Acetylaminofluorene
- ○ 4-Dimethylaminoazobenzene
- ○ N-Nitrosodimethylamine
- ○ Vinyl Chloride
- ○ Inorganic Arsenic
- ○ Lead
- ○ Benzene
- ○ Coke Oven Emissions
- ○ Cotton Dust
- ○ 1,2,-Dibromo-3-Chloropropane
- ○ Arylonitrile
- ○ Ethylene Oxide
- ○ Formaldehyde

- ☒ Flammable/Combustible Liquids
- ☐ Identification of, Handling and Storage of Hazardous Materials
- ☒ Handling Compressed Gas Cylinders
- ☐ Handling Cryogenic Materials
- ☐ Control of Radioactive Hazards
- ☐ Carcinogen Control Plan
- ☐ Handling Fine Dust
- ☐ Control of Radioactive Materials
- ☐ Bloodborne Pathogens
- ☐ Equipment Grounding

HAZARDS IN THE WORKPLACE (Continued)

- ☒ Glassware Cleaning, Handling
- ☐ Noise
- ☒ Laboratory Systems Under Pressure/Vacuum
- ☐ Protection from Magnetic Fields
- ☐ Lockout/Tagout
- ☐ Ergonomics
- ☒ Safe Use of Laboratory Ovens
- ☒ Signs, Labels, and Identifiers Required
- ☐ Protection From Electromagnetic Radiation
- ☐ Confined Space Entry
- ☒ High Temperature/Low Temperature

SPECIAL PROJECT SAFETY REQUIREMENTS

- ☒ Emergency Shutdown Procedures
- ☐ Construction Safety & Health
- ☐ Additional ES&H Personal Protective Equipment Requirements
- ☒ Additional ES&H Safety Systems/Devices
- ☐ Transportation of Hazardous Materials
- ☐ Planning and Preparedness for Operational Emergencies
- ☒ Unattended Operations
- ☒ Working Alone Policy
- ☐ Limitations for Working Continuous or Extended Hours
- ☐ Job Hazard Analysis for Operation of Concern
- ☐ Field Project Requirements
- ☐ Record Management
- ☐ Additional Fire Protection Requirements
- ☐ Motor Vehicle Safety
- ☐ Respiratory Protection, Ear Protection, Etc.
- ☐ Ventilation Requirements
- ☐ Identification of Necessary Safety Interlock Systems
- ☐ Additional Inspections
- ☐ Medical Examinations for Job functions
- ☐ Industrial Hygiene Exposure Monitoring and Surveying
- ☐ Safety Review Committee Requirements
- ☐ Safety Audits Necessary by Outside Consultants
- ☒ Document Control Procedures
- ☒ General Instrumentation Maintenance and Calibration

SPECIAL PROJECT SAFETY REQUIREMENTS (Continued)

- ☒ Development of Equipment Standard Operation Procedures
- ☒ Sample Chain of Custody

ENVIRONMENTAL COMPLIANCE

RCRA

- ☐ Hazardous Waste - Types & Quantities
- ☐ Disposal Cost
- ☐ Waste Minimization

Aboveground Storage Tanks

- ☐ Bulk Storage Requirements
- ☐ Permits
- ☐ Employee Training

Community Right to Know

- ☐ Extremely Hazardous Substances List - Types & Quantities
- ☐ Employee Training and Emergency Response

Clean Water Act

- ☐ Industrial Waste Discharge
- ☐ Stormwater Runoff
- ☐ Permits

Toxic Substances and Control Act

- ☐ PCB Usage and Storage

Clean Air Act

- ☐ Air Emissions Inventory
- ☐ Air Toxics List
- ☐ Permits
- ☐ Air Monitoring

NEPA

- ☐ Required Effort and Potential Environmental Consequences

Other

- ☐ Spill Response
- ☐ Field Project Requirements
- ☐ Pollution Prevention Methods
- ☐ Environmental Review Committee Requirements
- ☐ Spill Containment - Berms, Etc.
- ☐ Environment Audits Needed: Frequency/Method
- ☐ Other Environmental Compliance Issues